Muscle activities segmentation of EMG signal for manual lifting

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ABSTRACT – This paper presents the segmentation process using spectrogram for electromyography (EMG) signal analysis. Manual lifting activities are repeated to five times with the different load mass and lifting height are performed until achieve muscle fatigue to collect the data. The results show the technique used is able to differentiate between the contraction and baseline. Thus, contraction counted is able know the performance of the EMG signal. The increasing of load masses and high is inversely proportional to the muscle performance. The overall results conclude that, the application of spectrogram able to use in auto segmentation process for EMG signal.

1. INTRODUCTION

Manual lifting is commonly practiced by workers is one of the manual handling activities. In industrial workplaces, manual lifting is a prevalent choice that needed to perform a material handling task, although mechanized and automated equipment are provided [1].

Skeletal muscles are critically implemented to perform the manual lifting task. It is important to handle a suitable load mass and lifting height to ensure the muscles properly used to achieve muscle fatigue. Inappropriate lifting techniques will contribute to work-related musculoskeletal disorders (MSDs) in workplace injuries [2]. In general, the repetition of manual lifting tasks frequently may expose worker to the high risk of (MSDs) [1,2]

EMG signal is widely used and applied as a control signal in numerous man-machine interfaces' applications. It has also been deployed in numerous clinical and industrial applications. The EMG is known as biomedical signal that consist of electrical current. It is generated during contraction and relaxation phase of muscles [3]. Moreover, it is originally developed for investigating muscular disorder and EMG recording has also been used for studying the functional state of the muscle during various motions [4].

However, EMG signal is complicated and non-stationary signal with highly complex time and frequency characteristics. It is controlled by nervous signal because it always responsible the muscle activity [5]. During data collection and recording process, it become difficult because of EMG signal that really sensitive to noise and easier distorts while travelling through different tissues in the body muscle. Feature extraction and function classification is the key in processing and analysing the EMG signals [4,5].

A lot of studies have been done in EMG signal investigation especially in extraction of EMG signal [3]. The previous researchers have been used fast Fourier transform (FFT) to analyse the EMG signal, but this technique has the limitation to cater non-stationary signals with variable frequency and amplitude as EMG signal [4].

In this research work, time frequency distributions (TFDs) which is spectrogram is employed to analyse the performance of the subject in doing the manual lifting task by the variable high of lifting height and mass of load. The parameters of instantaneous root mean square (RMS) voltage and current of EMG signal are extracted from time-frequency representations of spectrogram in order to give clear information on manual lifting behaviour.

2. METHODOLOGY

10 subjects had to lift the 5kg and 10 kg load mass with 70 cm and 140cm of height for symmetric angle (0°) to test the contraction produces by right biceps. The lifting frequency is constant at 4 lifts/min. There were four lifting tests performed which consist of five replication. Ten minutes taken for each test to produce f repeating EMG contraction. Each lifting was divided into four phases as in the Figure 1. The details for the phases are shown as follow:

Phase 1: Subject takes the load
Phase 2: Traveling the load onto the shelf
Phase 3: Place the load onto the shelf
Phase 4: Release the load

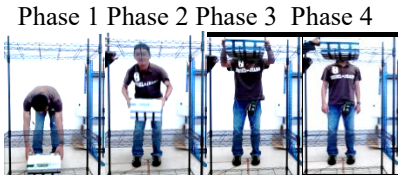

Figure 1 Four phases involved in each lifting

2.1 Segmentation process

EMG segmentation is the superposition of the lifting (contractions) to the several motor units. The segmentation of EMG signal is necessary to understand the mechanism that related to the muscle. This procedure is most commonly used in EMG signal analysis. Based on the recorded EMG signal in manual lifting activity, the important signal can be identify and able to be analyses.

The segmentation involves the separating a signal into regions corresponding to the signal properties, the difference in the signal instantaneous energy holds a good measure to distinguish between the object of interest (muscle activation) and the rest (baseline and noise). One of the methods for segmentation regions is through thresholding technique, the separation between muscle activation and the baseline plus noise.

Threshold is created based on equation (1) from binary number by turning all values below a certain threshold to zero (minimum) and all values above the threshold to one (maximum) in order to establish for an attribute, characteristic or parameter as benchmark for comparison for reviewing the situation in a system.

$$M(t) = \begin{cases} 1 & if\ E(t) \geq E_{thres} \\ 0 & otherwise \end{cases} \quad (1)$$

Where $M(t)$ is the threshold version of $IE(t)$ at some global threshold E_{thres}. $E(t)$ is the instantaneous energy as shown in Equation (1). From the threshold of instantaneous energy, the segmentation for the raw signal, $X_s(t)$ for can be obtained in Equation 2 as follow:

$$X_s(t) = x(t).M(t) \quad (2)$$

3. RESULTS

Figure 2 shows the segmentation of EMG signal sample for manual lifting The segmented of raw signal also to detect the number of liftings. It would be able to detect the contraction occurred automatically in the manual lifting tasks. The threshold should be in parallel diagram of the raw signal and the instantaneous energy to see two or more separate modes can be identified. By different threshold setting, the values may result of losing too much of the muscle activation signal or sometimes getting too many unnecessary signals (baseline and noise).

4. CONCLUSION

In the nutshell, it is show that the application of segment process is help to differentiate EMG signal (number of contraction) and the noise also baseline. It make easier for the researcher to analyse the muscle acitivities.

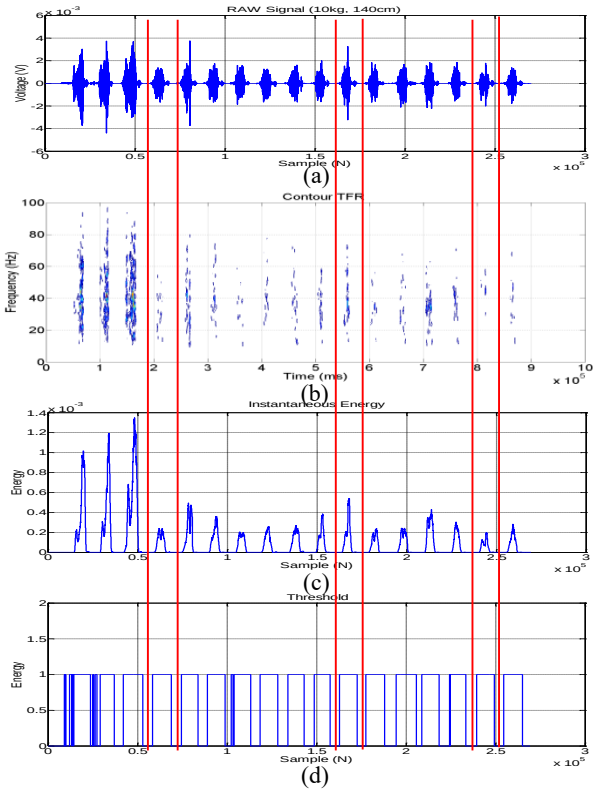

Figure 2 task of lifting: (a) raw signal of manual lifting task, (b) spectrogram representation, (c) instantaneous energy, (d) threshold calculation

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